

Clean and Efficient Use of Fossil Energy for

Power Generation in Thailand

APEC Presentation

1 November 2000



Clean & Efficient Use of Fossil Energy

- **SAFE & CLEAN**

- ✍ Vapor & Air Emission
- ✍ Liquid & Solid Waste
- ✍ Water Consumption & Discharge
- ✍ Other Concerns

- **EFFICIENT**

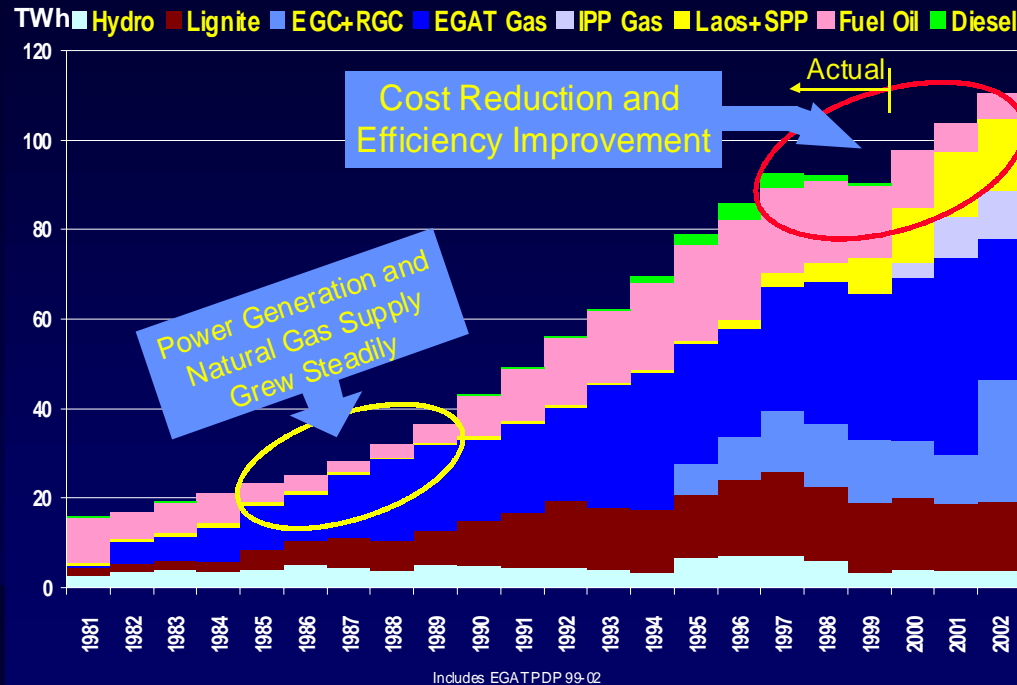
- ✍ Capital Investment Efficiency
- ✍ Thermal Efficiency
- ✍ Operation & Maintenance Cost
- ✍ Capacity Factor & Service Life

EGAT's Fuel Utilization Criteria

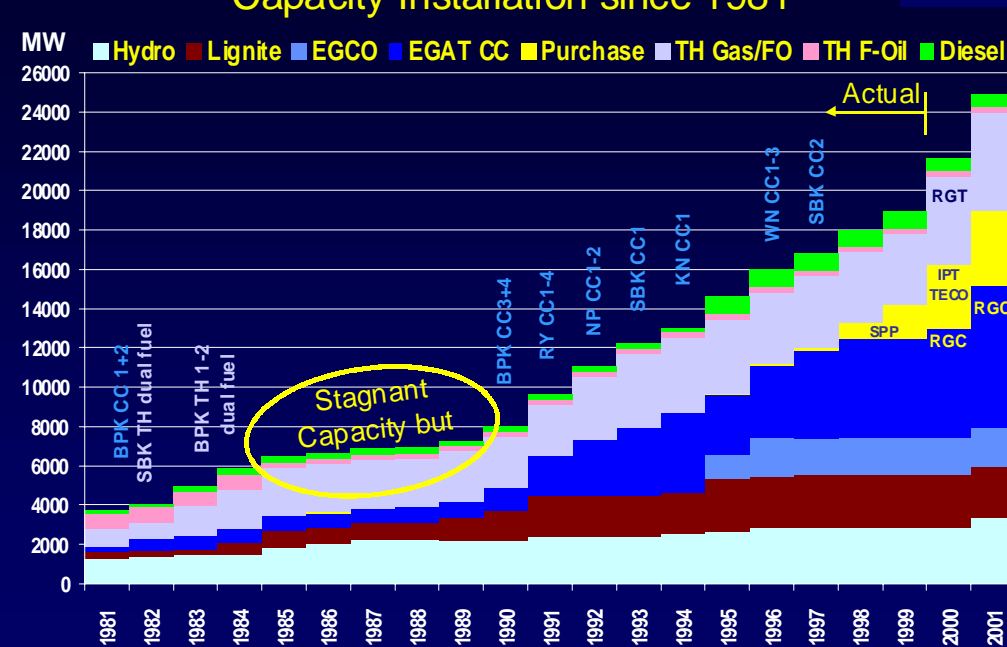
- **Supply & Availability**
 - ✍ **Now & Long Term**
- **Prices**
 - ✍ **Stability & Predictability**
- **Least Cost Option**
 - ✍ **Life-Cycle Cost**
- **Fuel Diversification**
 - ✍ **Multiple Types**
 - ✍ **Multiple Sources**
- **Environmental impact**

Thailand's Power Generation Capacity & Energy

EGAT GWh Generation



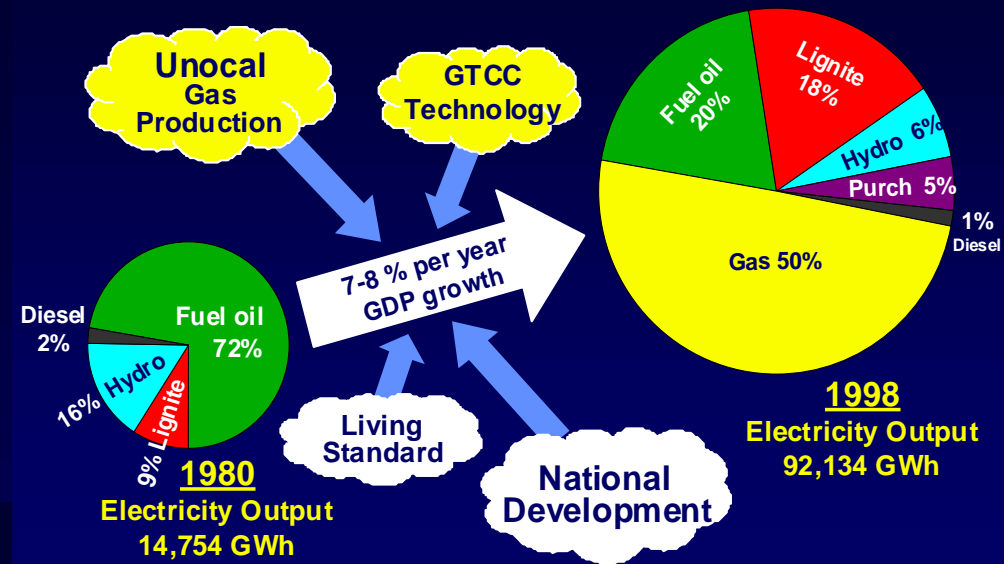
EGAT incorporated NG availability in
Capacity Installation since 1981



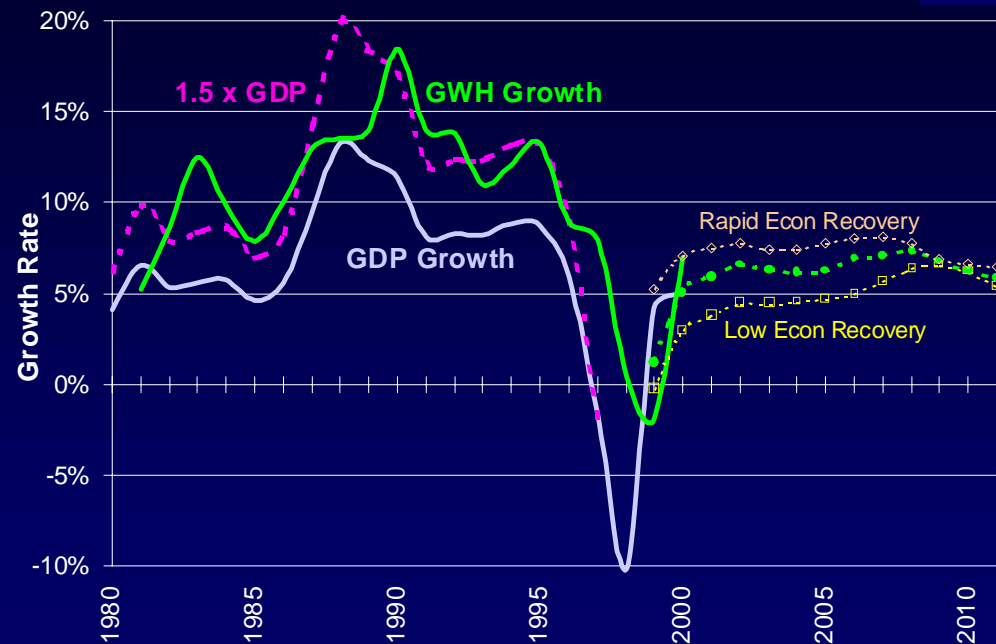
Historical Growth
Impressive
GAS is KEY

Thailand's GDP & Electric Energy Generation

Natural Gas Fuels Thailand's Power Supply and National Development



Thailand's GWH grew @ 1.5 x GDP

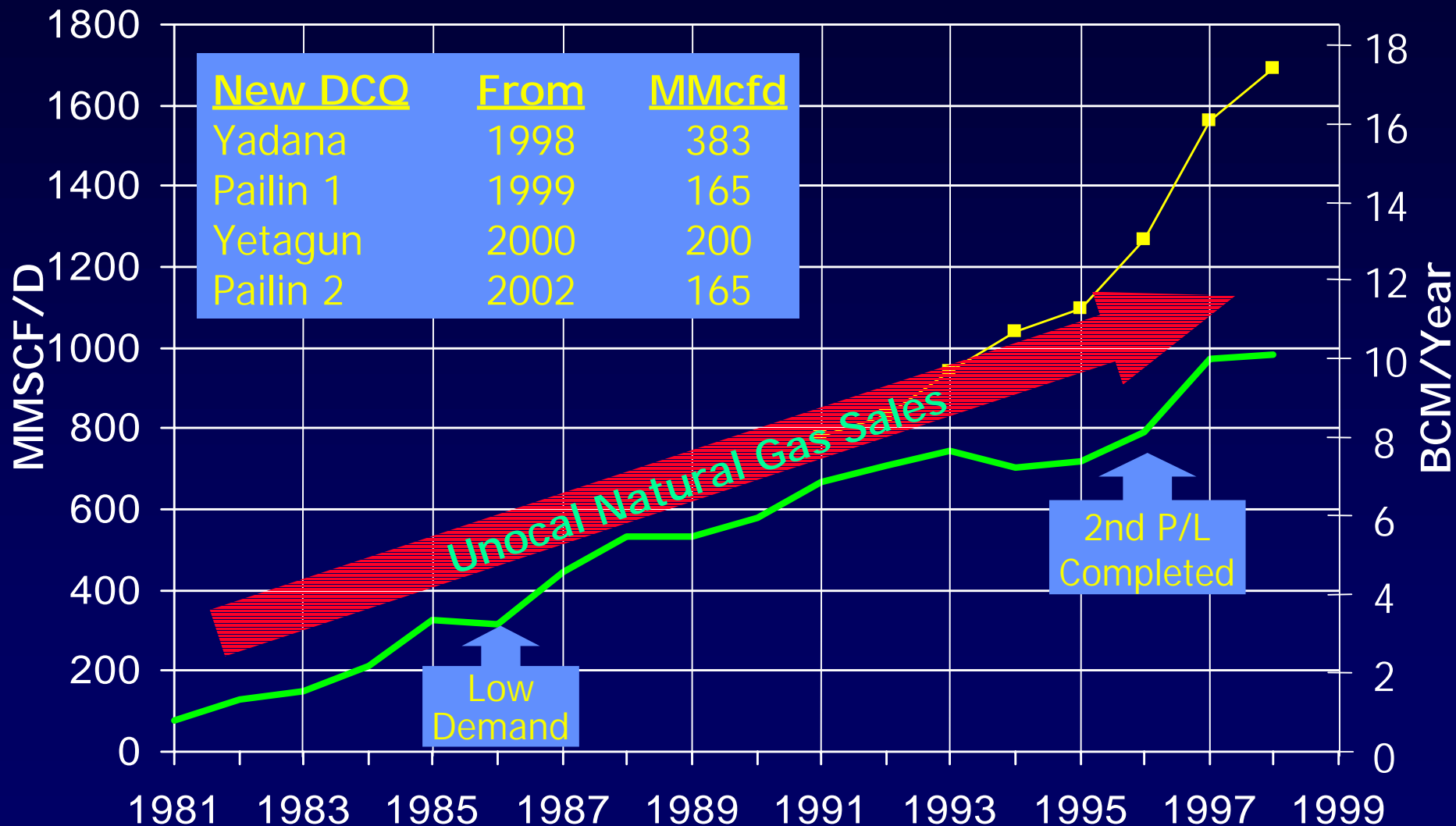


**GAS supplied
50% of GWH**

EGAT's Fuel Utilization Criteria

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Natural Gas Supports Thailand's Growth since 1981



There is Plenty of Gas for Thailand

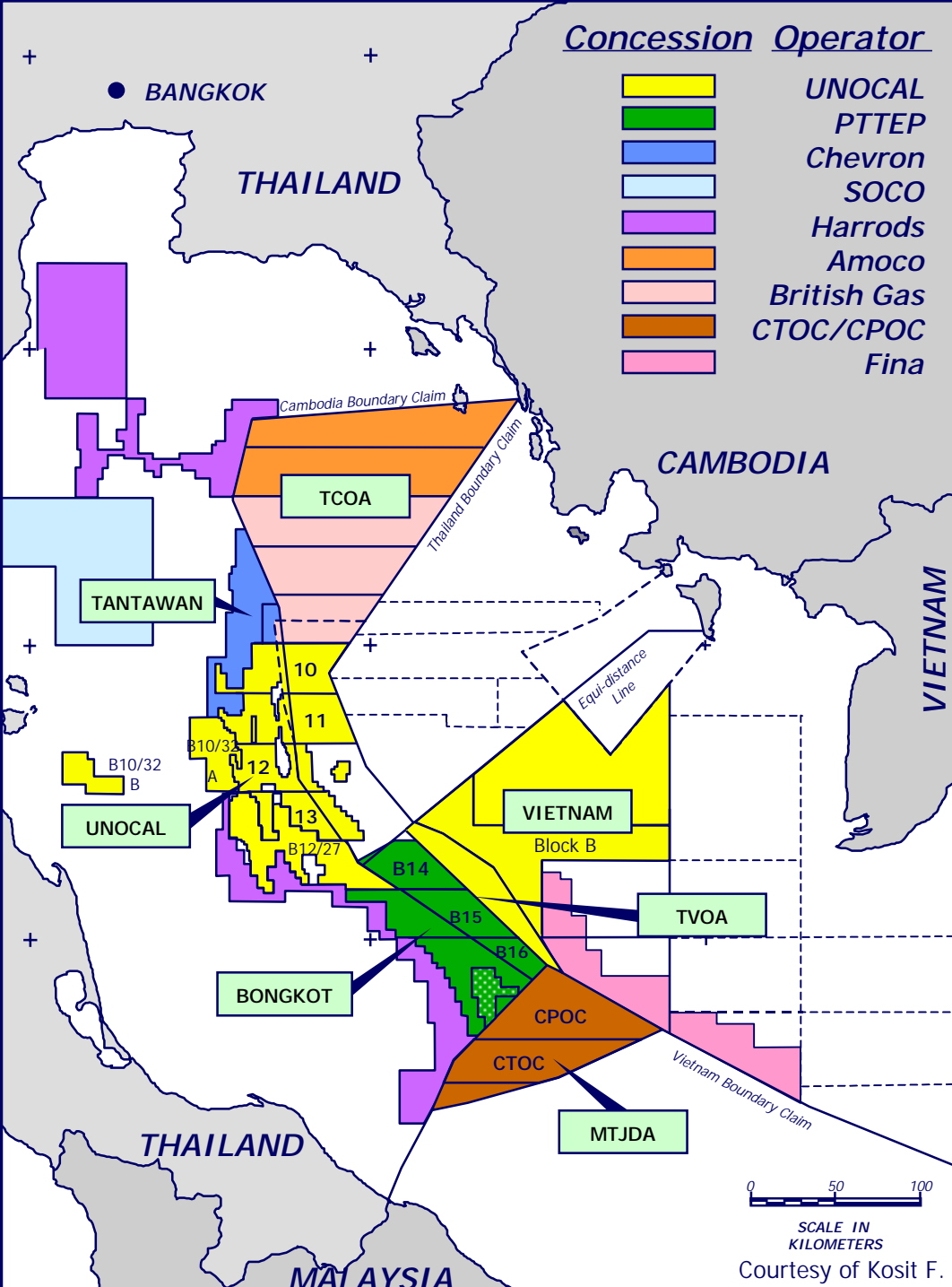
- Total resources in the region 40-60 TCF

- Thailand consumed ~ 4 TCF from 1981 to 1999

✍ Resources in the region > 10 times

- At 1999 consumption rate of ~ 1.8 bcfd

✍ Resources will last ~ 60 years



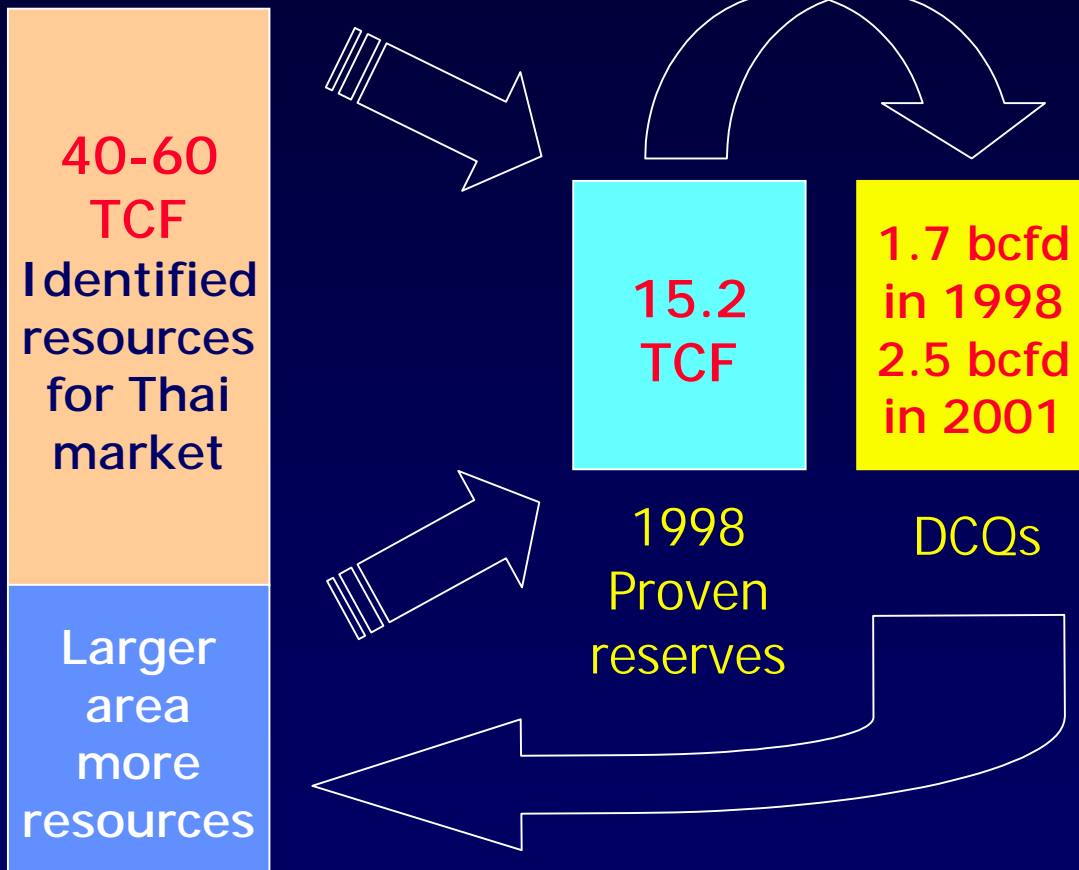
GULF OF THAILAND AND REGIONAL GAS RESOURCES

<u>Producing</u>	<u>TCE</u>
Unocal - remaining (total 12, produced 4)	8
Bongkot	5 - 7
Tantawan+	0.7 - 3
Yadana	5 - 7
Yetagun	<u>2 - 3</u>
Subtotal	<u>21-28</u>
<u>Future</u>	
MTJDA	14
TVOA (Artit)	5 - 7
Vietnam	2 - 7
TCOA	<u>0.5 - 3</u>
TOTAL	<u>42 - 59</u>

Natural Gas resource development

LONG and **LARGE** up-front investments - driven by market demand.

Once a market is established, more reserves will be proved-up to capture additional sales.



Market/GSA drive to prove-up more reserves for additional DCQs

HIGH RISK ENDEAVOR

Estimated up-front cost to prove-up reserves prior to a GSA signing :

	<u>US\$ MM</u>
• Seismic	4 - 20
• Exploration drilling (6-25 wells)	20 - 70
• Evaluation and reserves assessment	1 - 5

Total \$25 - \$100MM

or 1 - 4 Billion Baht

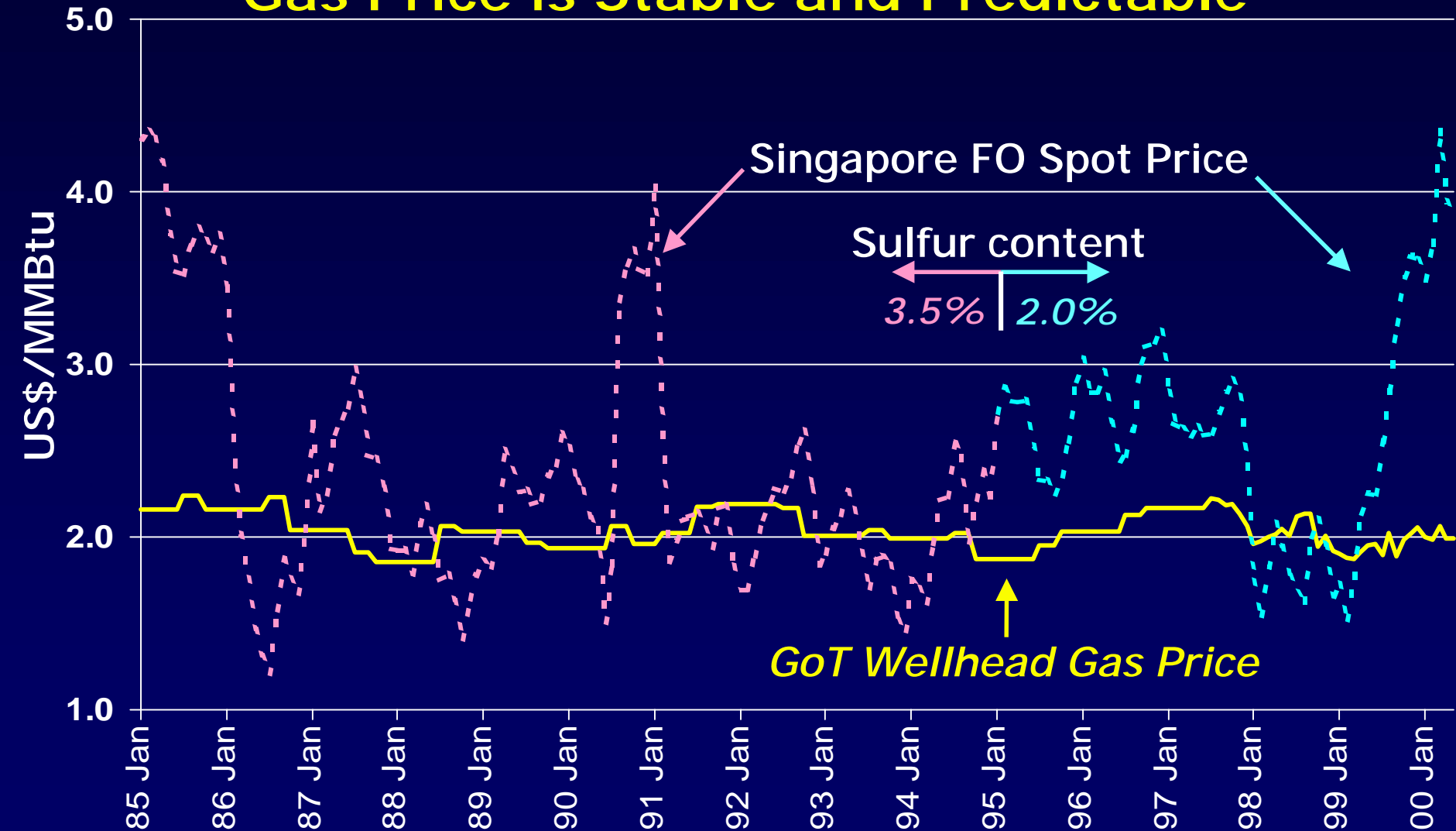
EGAT's Fuel Utilization Criteria

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Natural Gas more ECONOMICAL than Fuel Oil

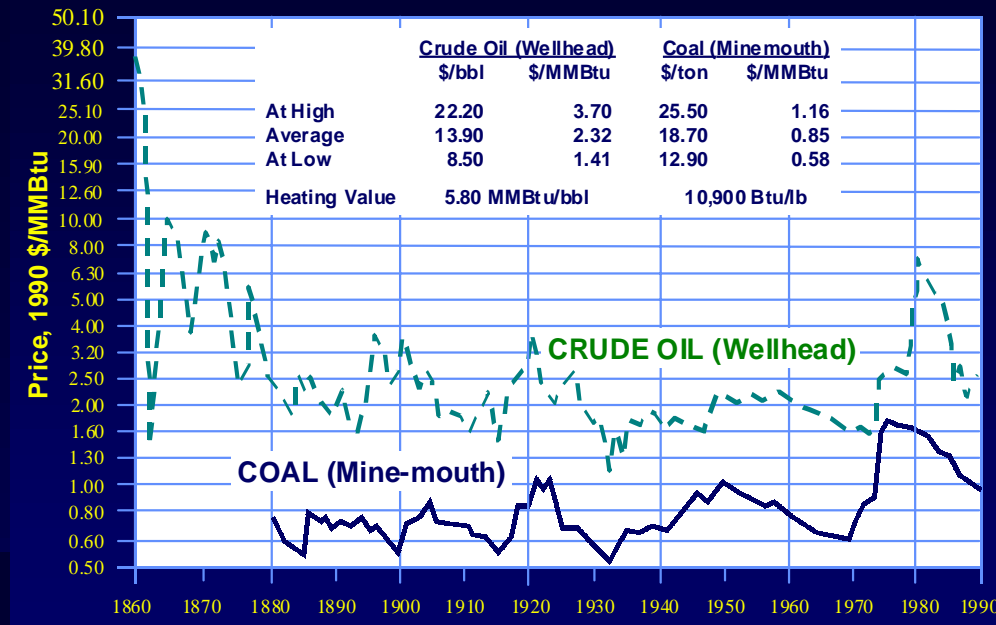
US\$/MMBtu (nominal)

Gas Price is Stable and Predictable

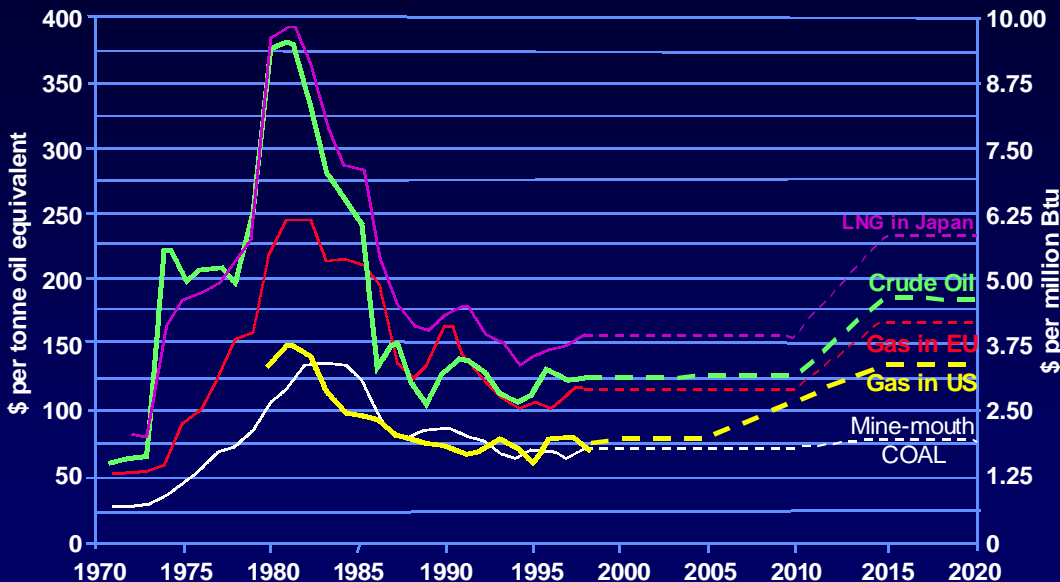


Energy Price Forecast

CORRECT or NOT



Fossil Fuel Prices
(Constant 1990 \$)



ALL TYPES
FOLLOW
SAME TREND

EGAT's Fuel Utilization Criteria

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- ✍ **Now & Long Term**

- **Prices**

- ✍ **Stability & Predictability**

- **Least Cost Option**

- ✍ **Life-Cycle Cost**

- ✍ **Capital Investment Efficiency**

- ✍ **Thermal Efficiency**

- ✍ **Operation & Maintenance Cost**

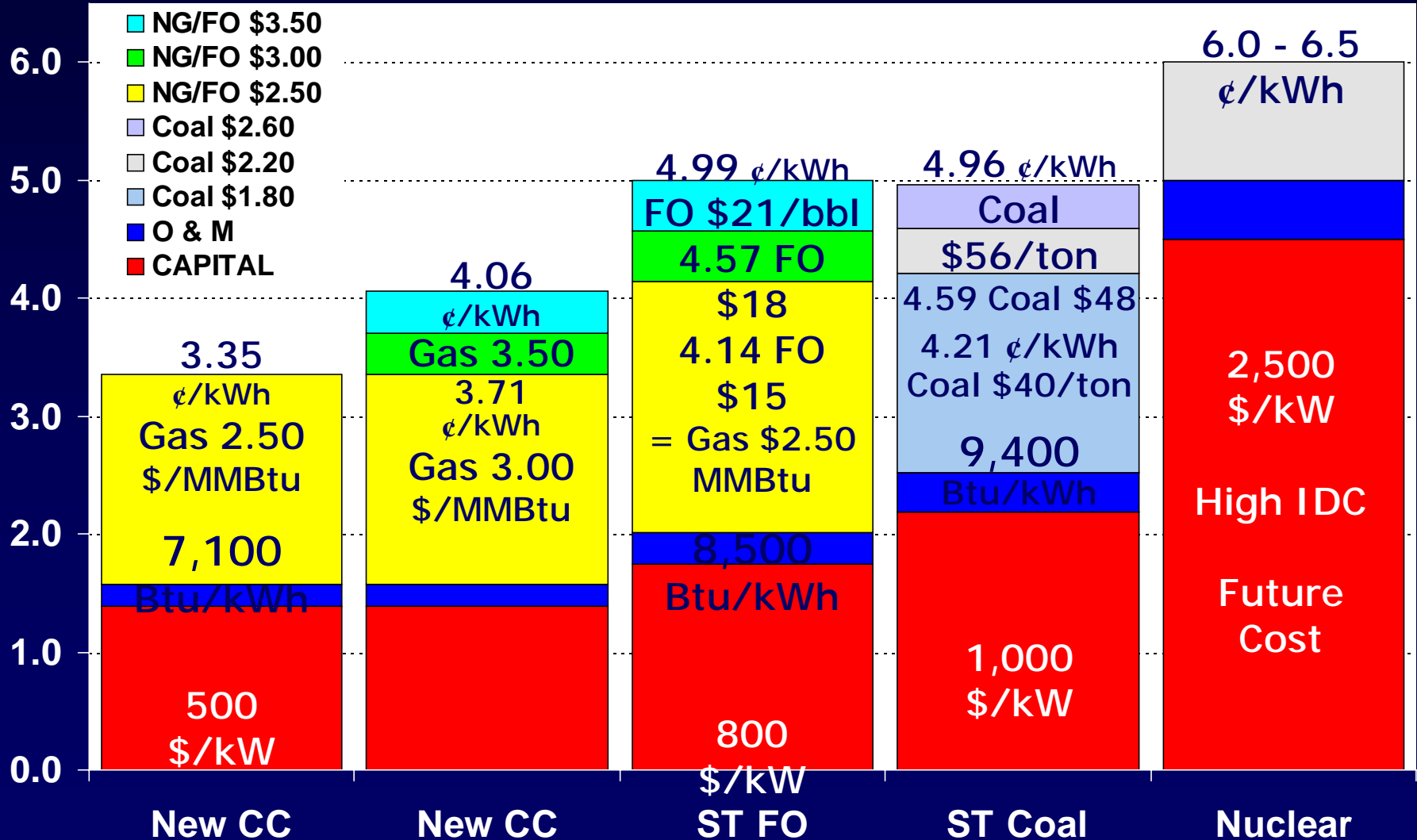
- ✍ **Capacity Factor & Service Life**

Gas Fired GTCC Beats Alternatives

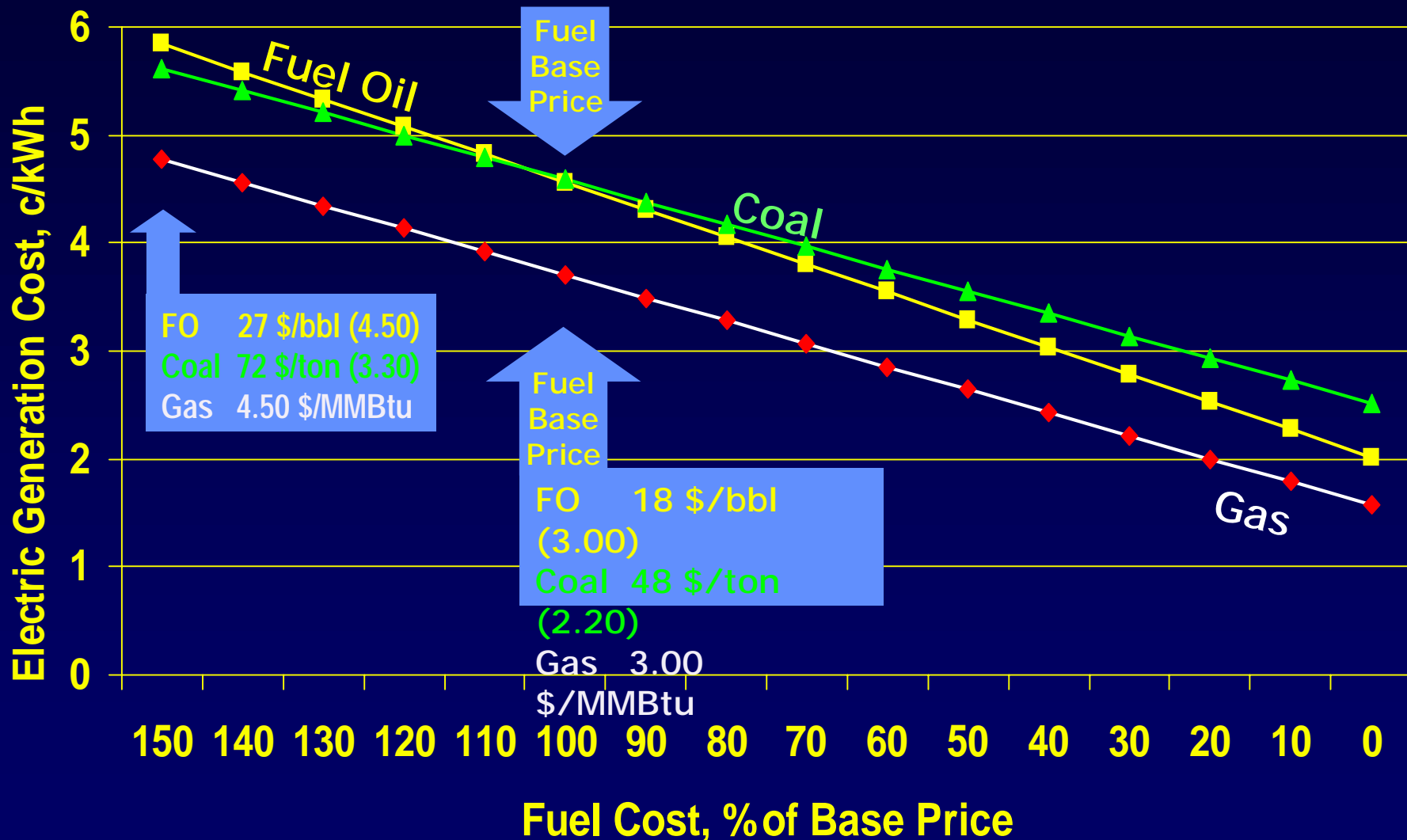
(Gas Prices @ 2.50, 3.00, 3.50 \$/MMBtu)

¢/kWh

POWER GENERATION COST @ 80% CAPACITY FACTOR



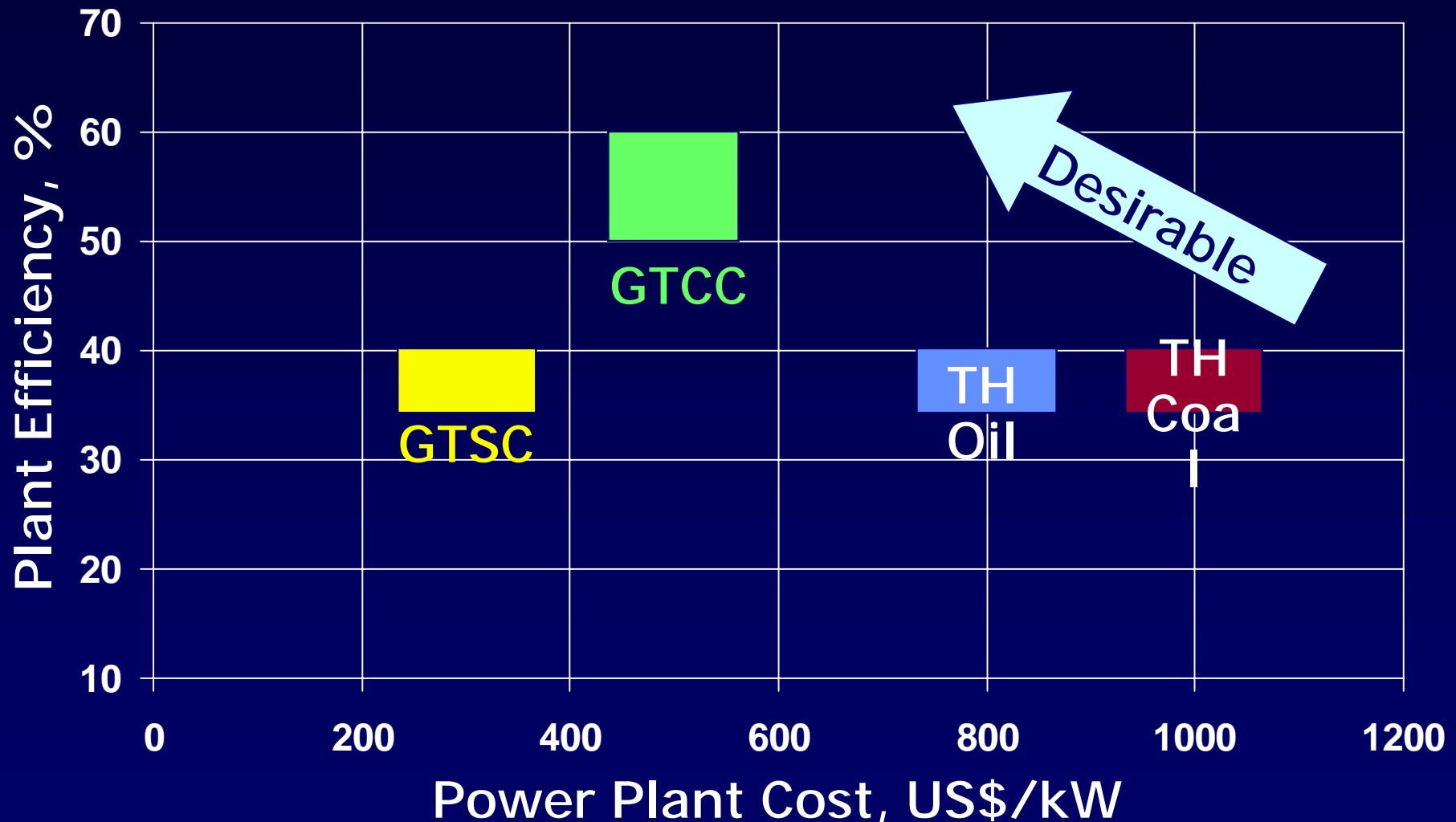
Natural Gas Most Economical in GTCC Power Plant



Natural Gas “Fuel of Choices” in New GTCC

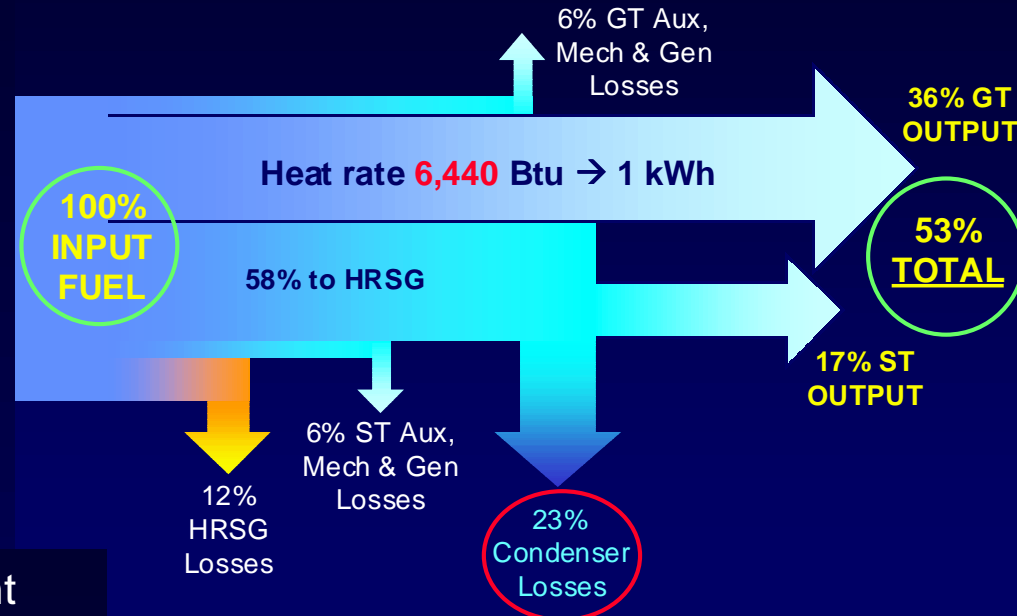
Lowest Cost @ Highest Efficiency

(700 MW Block, Plant Cost in 1995-1997)

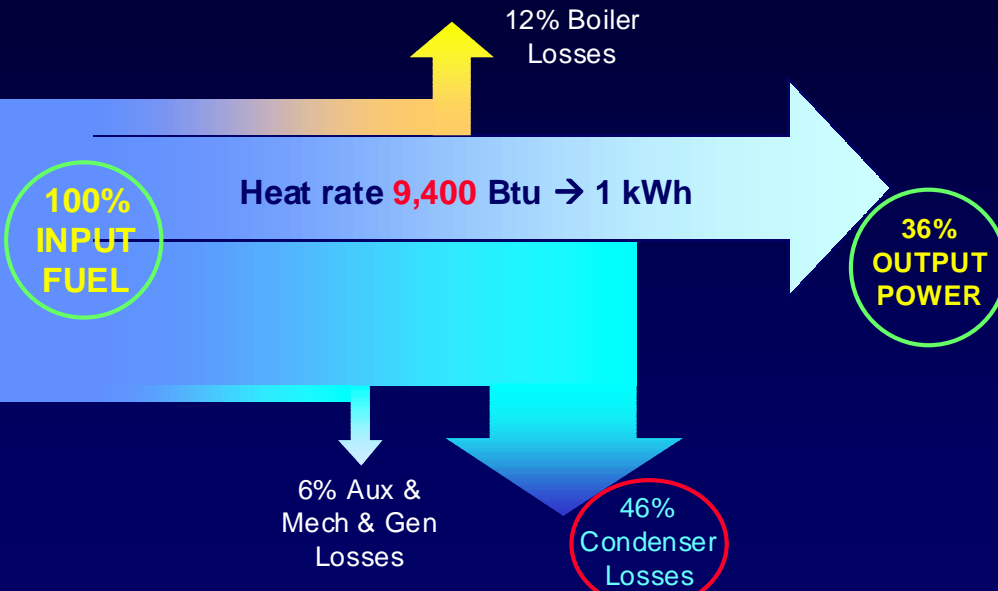


Gas-fired GTCC More Efficient Than Coal-fired Power Plant

Gas Turbine Combined-Cycle 53% Efficient
Achievable in Thailand



Coal Thermal Power Plants 36% Efficient
46% Condenser Losses

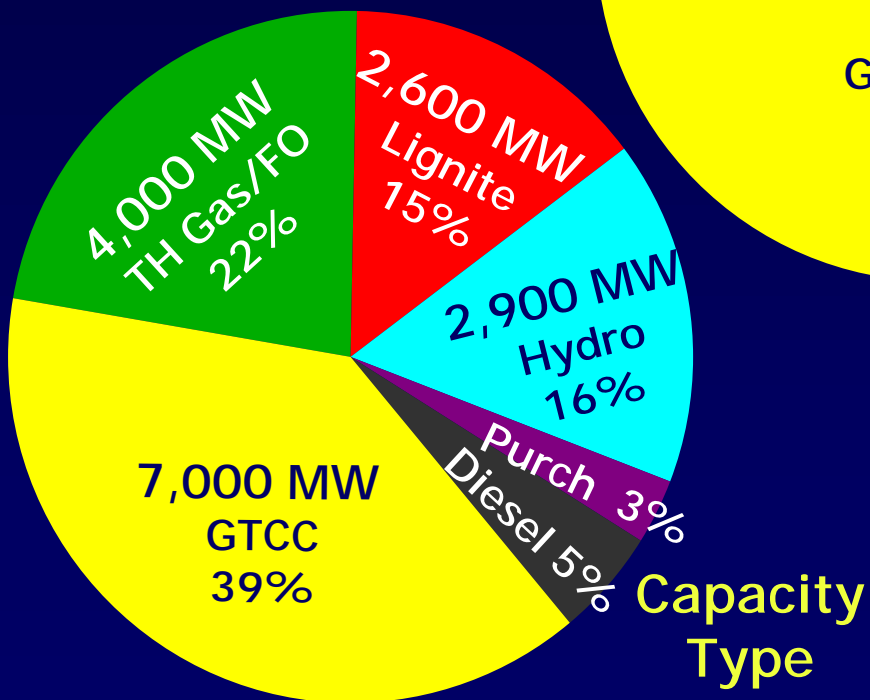
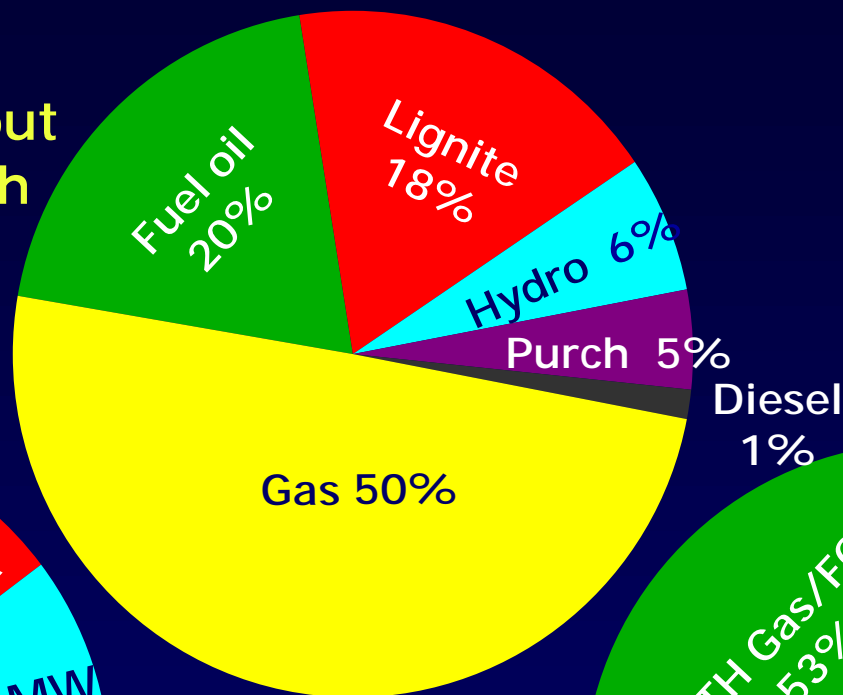


Gas-fired GTCC
Environmentally
Friendly

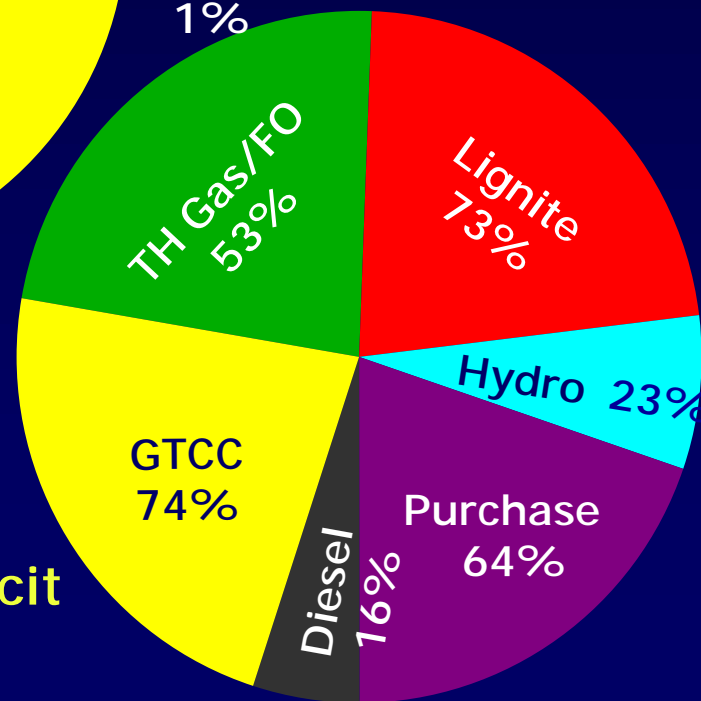
Thailand 18,174 MW Capacity in 1998

NG yielded 50% Power Output

Energy Output
92,134 GWh



Capacity
Factor

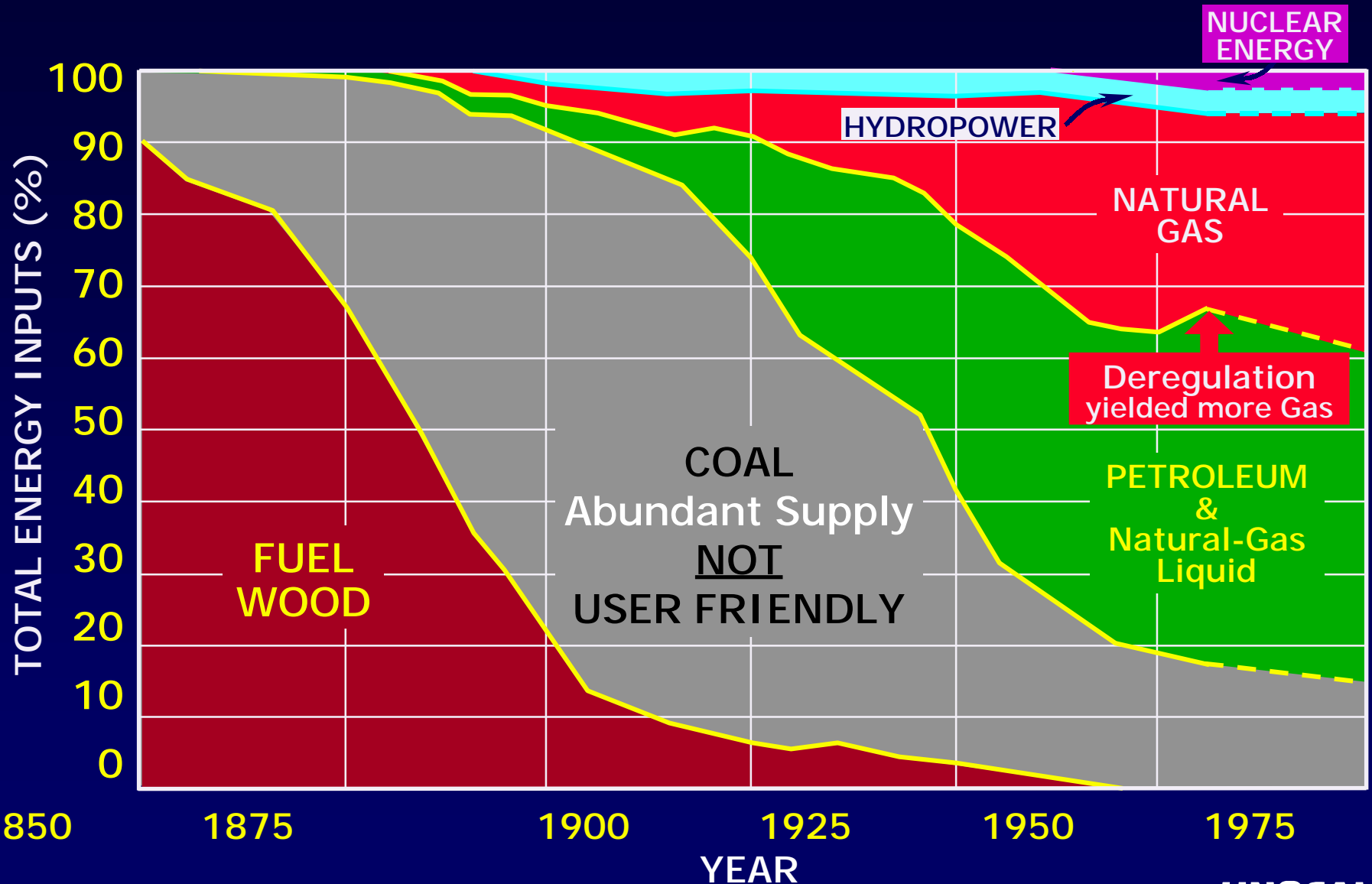


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Energy Supply Evolution in USA

Natural Gas ✍ Fuel of Choice ✍ Next 50 Years, WHY?



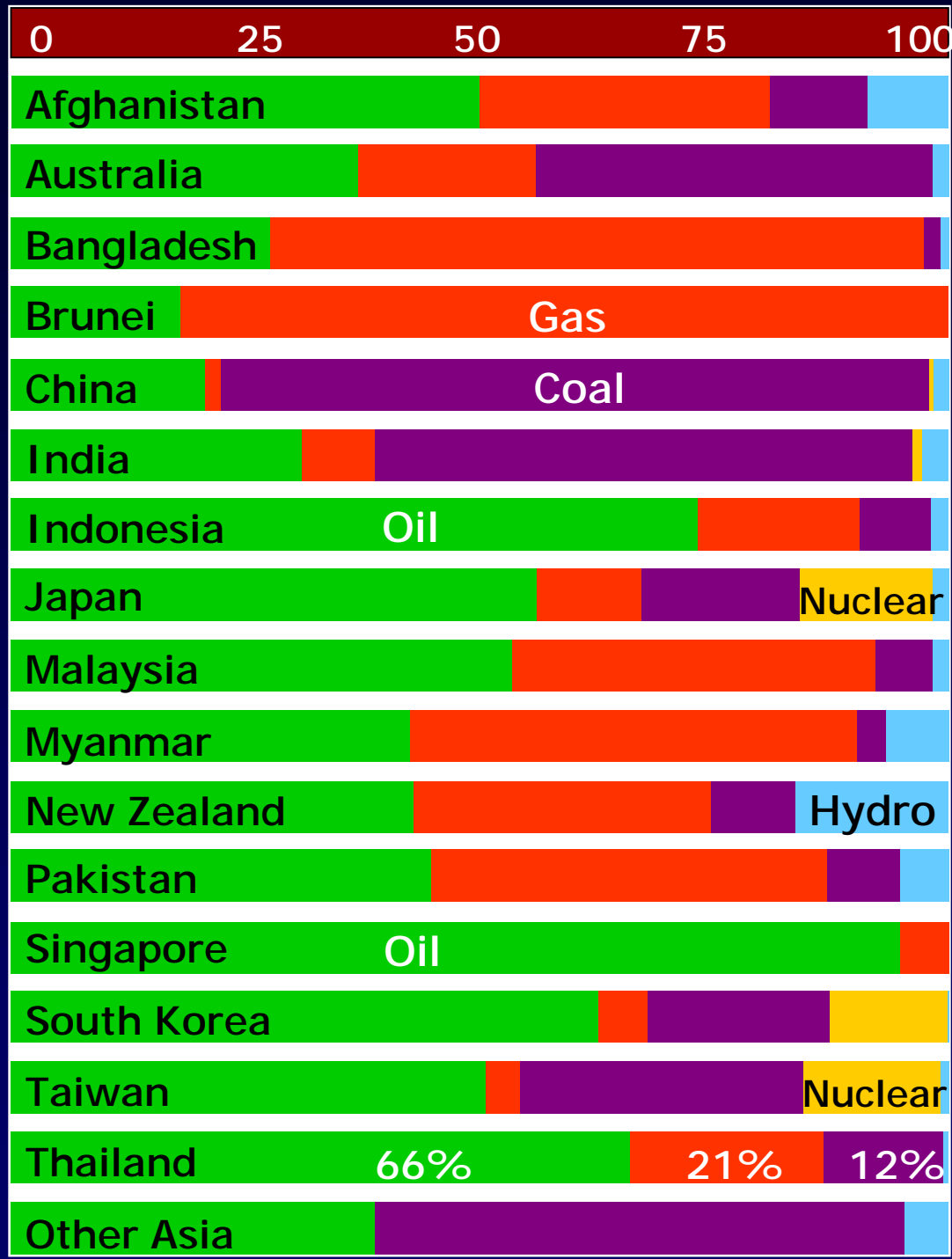
UNOCAL⁷⁶ introduced
NG
to Thailand in 1981
Natural Gas has become
Fuel of Choice

Asia & Australia Primary Energy Consumption

Each country optimizes energy
supply portfolio based on its own
available resources
(indigenous & imports)

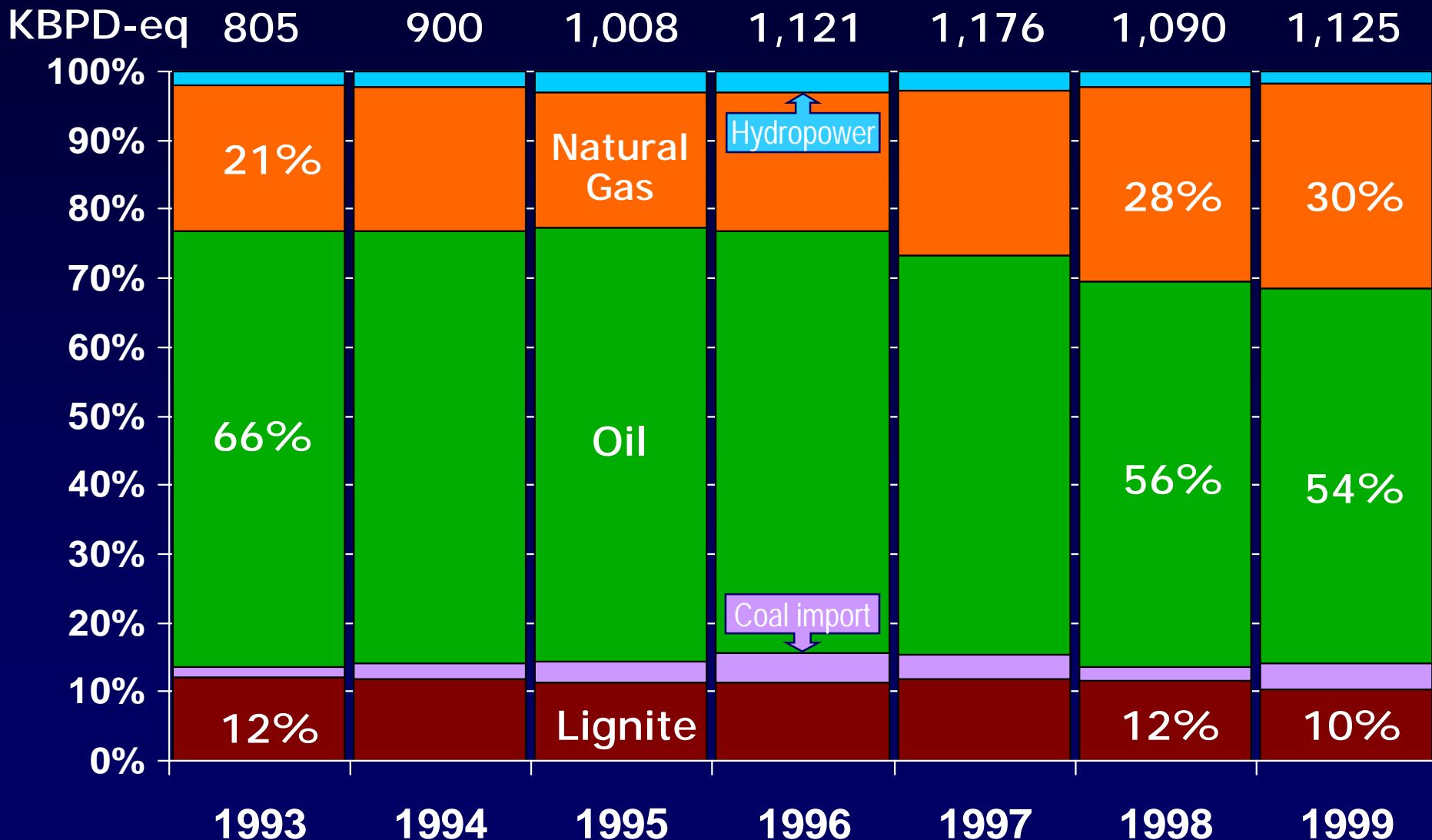
Japan, Singapore,
South Korea and Taiwan
import most of their energy
needs

1993



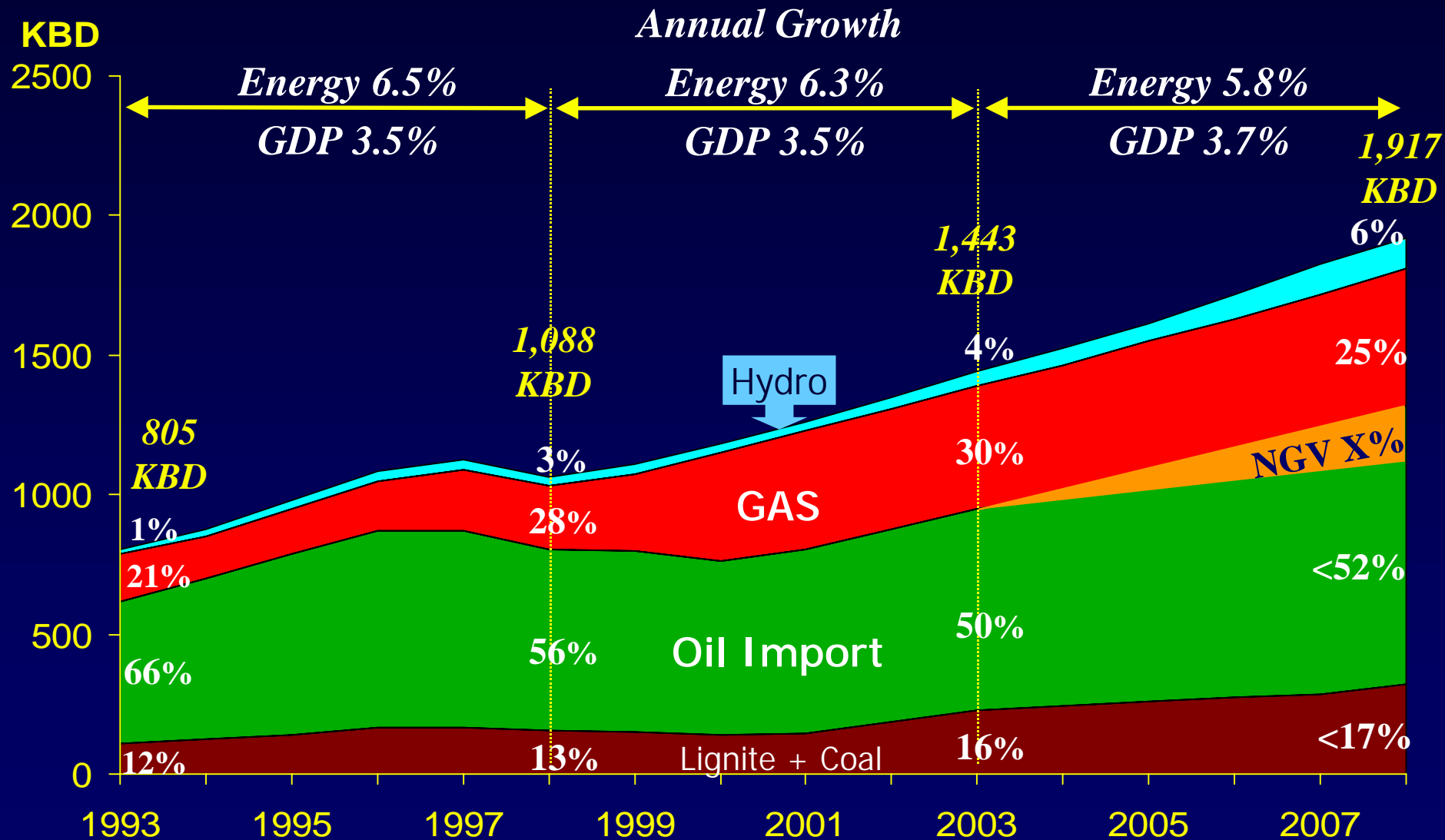
Thailand Primary Energy Consumption

Natural Gas “Fuel of Choice”



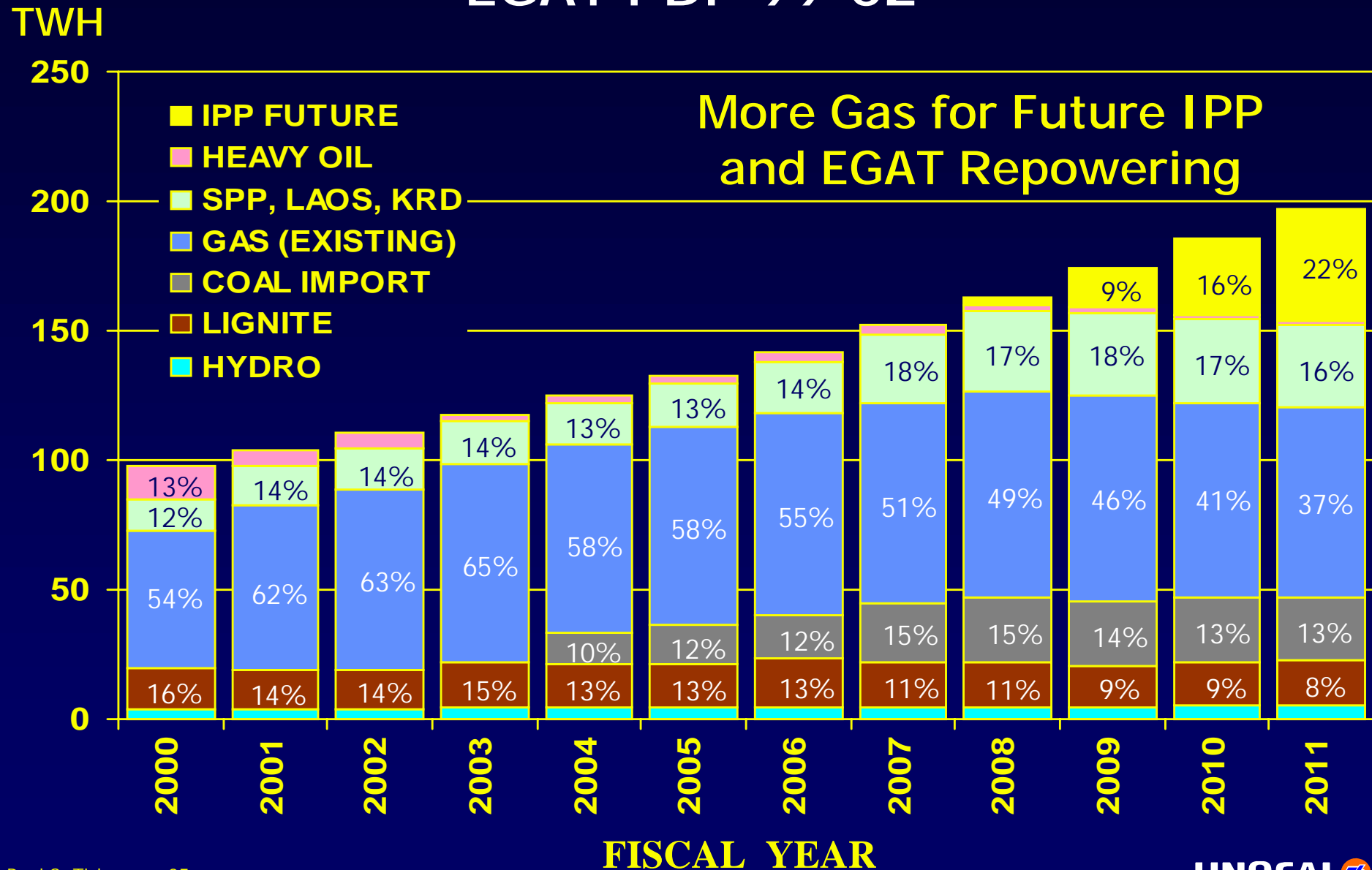
Thailand's Primary Energy Consumption Forecast

NGV likely increases GAS consumption



FORECAST OF ENERGY GENERATION

EGAT PDP 99-02



More Resources and
Pipeline Infrastructure
to Support
Growing
Natural Gas Market

Natural Gas Supply

UNOCAL 76

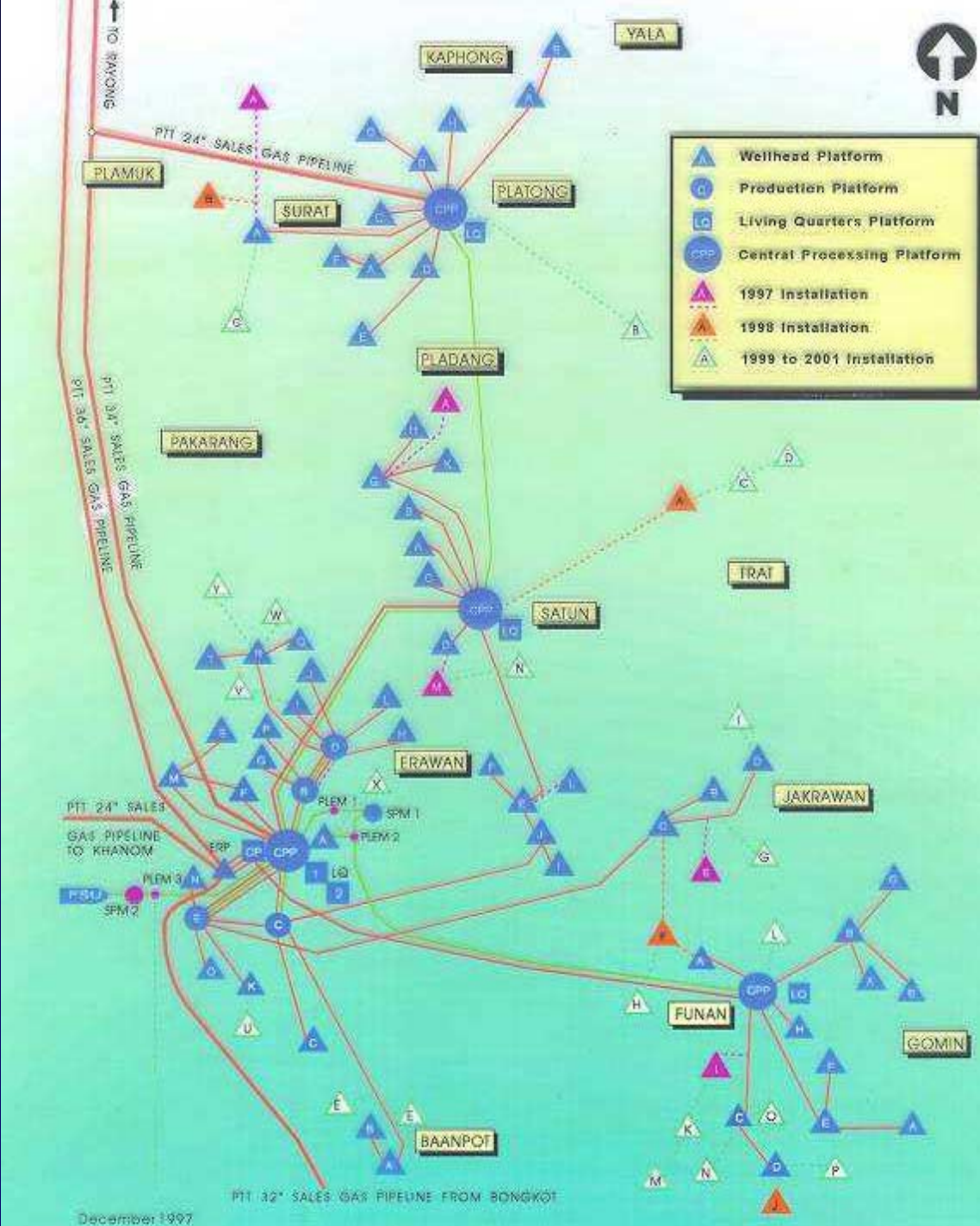
continuously evaluating
NG supply sources for
near-term and
long-term needs



Courtesy of Kulnatee N.

UNOCAL Thailand Offshore Structures

- 1401 wells drilled
- 73 wellhead platforms
- 4 production platforms
- 5 central processing platforms
- 6 living quarters
- 1 gas compression platform
- 771 kms interfield pipelines



EGAT's Fuel Utilization Criteria

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Clean & Efficient Use of Fossil Energy

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IPT Gas-Fired GTCC Lowest Air Emission (7% O₂ in dry flue gas)

Could ALL meet the CLEAN STANDARD for GAS?

Air Emission	IPT		Thai Standards		
	Gas	Diesel	Gas	Fuel oil	Coal
• SO _x , ppm, >500 MW 300-500 MW <300 MW	<5	32	20	320	320
				450	450
				640	640
• NO _x , ppm	99	148	120	180	350
• CO, ppm	40	240	---	870	870
• Particulate, mg/Nm ³	16	60	60	120	120

How much will it cost?

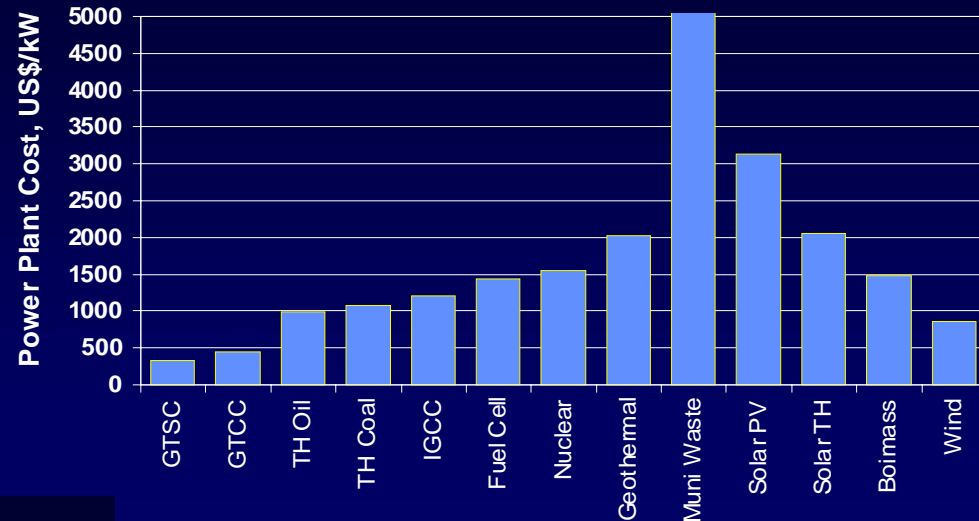
Natural Gas Most Economical Fuel with other Advantages

- **Handling, Flow via Pipeline**
 - ✍ Safe & Clean
 - ✍ Simple & Convenient
 - ✍ No Storage / No Stock Pile
- **Operation**
 - ✍ No Carrying Cost
 - ✍ Non-Corrosive (negligible Sulfur, No Vanadium)
 - ✍ Minimum Downtime, Low Turn-around Cost
- **Environmental Benefits**
 - ✍ Lowest Air Emission
(NO_x, SO_x, CO, ROG, Particulate)
 - ✍ Low Water Consumption
 - ✍ No Hot Water Discharge
 - ✍ No Solid Residue

Thailand's Natural Gas Supply ABUNDANT & MOST ECONOMICAL

Instant 1996 Capacity Cost
(IDC and other costs to be added)

Some Types **CANNOT** Deliver Power at All Time



Adapted from Energy Information, US Department of Energy
Source: Deutsche Bank, Asia - Power/Utilities, October 1999

Power Generation Choices

Non-conventional

- Solar
 - Photovoltaic Cell
 - Solar Thermal
- Wind
- Hydro
- Tidal
- Geothermal
- Bio-mass
- Municipal Waste
- Fuel Cell
 - Phosphate
 - Moltencarbonate

Conventional Fuel

- Natural Gas & LNG
 - GT Combined-Cycle
 - GT Simple-Cycle
 - Thermal Steam
- Petroleum
 - Off Gas, LPG, NGL
 - Clear Oil
 - Dark Oil
 - Petroleum Coke
- Coal & Orimulsion
 - Thermal Steam
 - IGCC
- Nuclear

IGCC converts low grade fuel to GAS for GTCC
Gas-fired GTCC can be refueled with coal
via IGCC when economical

Gas-fired GTCC
CLEAN &
EFFICIENT

VISION

To be the world's **leading** energy resource
and project development company

Best People Best Partner Best Performance

To improve the lives of people wherever we work

Honesty Integrity Excellence Trust

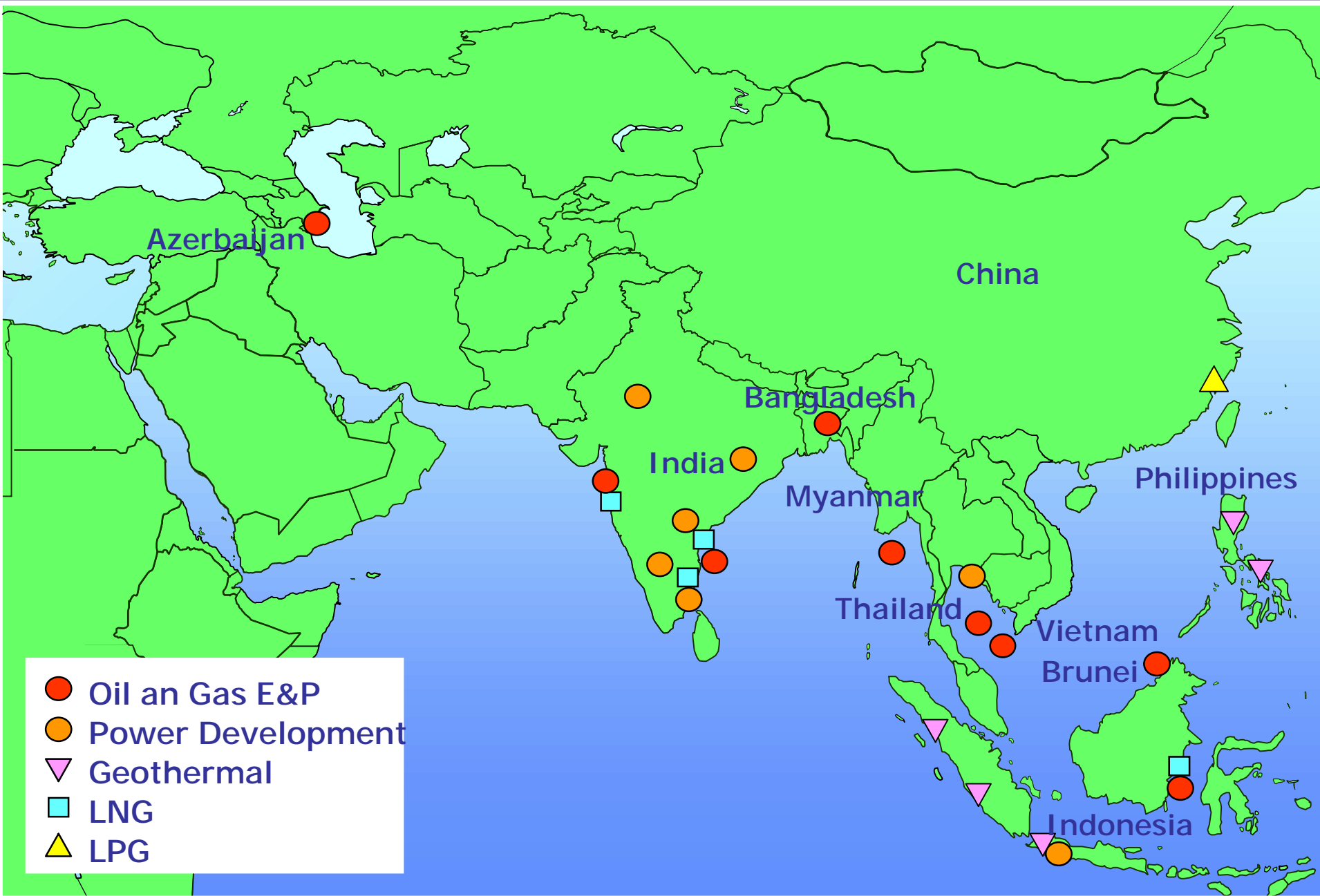
UNOCAL 

VALUES

Unocal Operations Worldwide



UNOCAL ⁷⁶ *In Asia*



UNOCAL Strength

- World Largest - Publicly Traded - Independent Energy Resource Company
- Strong Balance sheet
- Over 110 years in Petroleum Business
 - ✍ UOC incorporated on 17 October 1890
- Over 38 years business in Thailand
- Experienced in power business
 - ✍ World largest geothermal producer
- Unique Cogeneration Capability
 - ✍ Refinery & Chemicals Cogeneration
- Fuel supply management with large reserve base

Acknowledgements

References :-

- Electric Utility Systems and Practices, Fourth Edition.
General Electric Company, John Wiley & Sons (Copyright ? 1983)
- GE Power Generation, 39th GE Turbine State-of-the-Art Technology Seminar.
- Gas Turbine World 1998-99 Handbook.
- EGAT Power Development Plans, several editions.
- Thailand National Energy Policy Office (NEPO), data from web site.
- Asia - Power/Utilities, Deutsche Bank, October 1999
- World Energy Outlook, International Energy Agency, 1998 Edition
- BP Review of World Gas, 1994 Edition.
- Pramote S, ML Peekthong T, Nisa K and Parames K provided several slides.
Thanks to Konthi K. for editing this second edition.

I am grateful to my mother, father and all of my teachers. I am grateful to Unocal and many people who helped me throughout my career. Special thanks to Dr. Ian R. Straughan who taught me many things on power business.

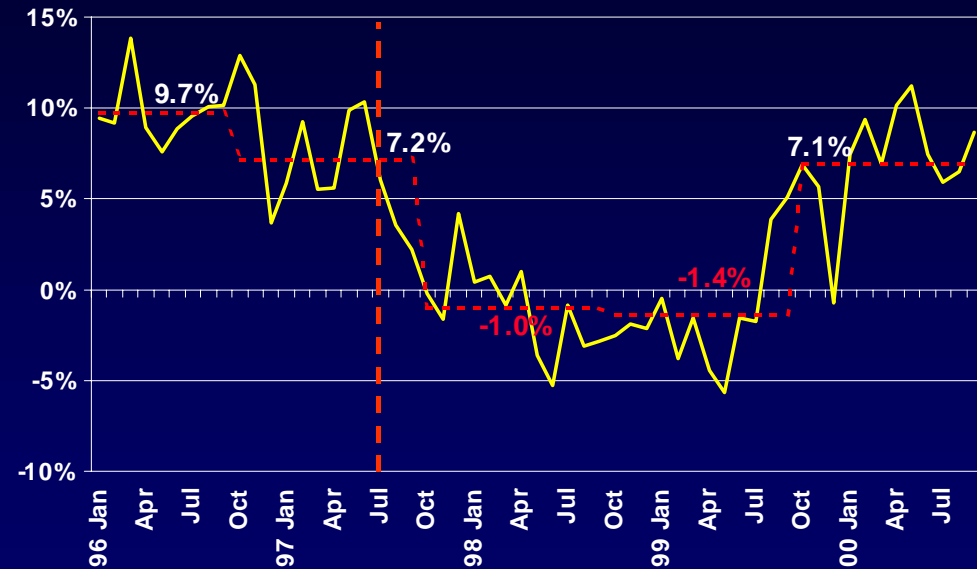
I dedicate this work for the well being of the world, the Thai people and specially to my family for their understanding, support and sacrifice.

Copyright ? 1999, 2000 by Paul S. Tish (paul.tish@unocal.com)

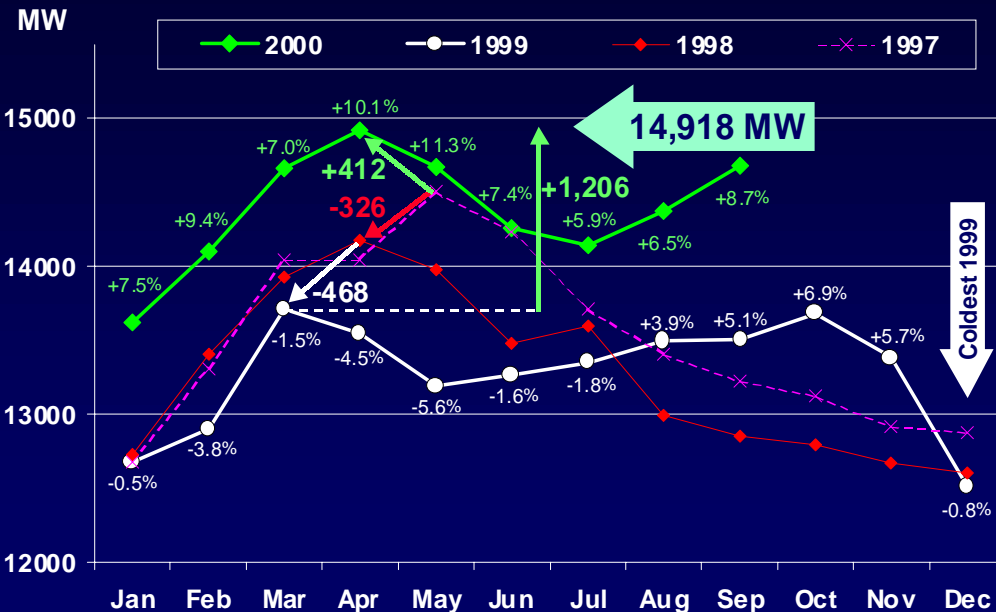
This document does not necessarily reflect the views or policies of Unocal.

Thailand's Electric Capacity Peak Demand

Y-o-Y Peak Demand Growth Rate



EGAT 1997-2000 Monthly Peak Demand
(ambient temp ↓ 1°C ⇒ peak demand ↓ 200 MW)

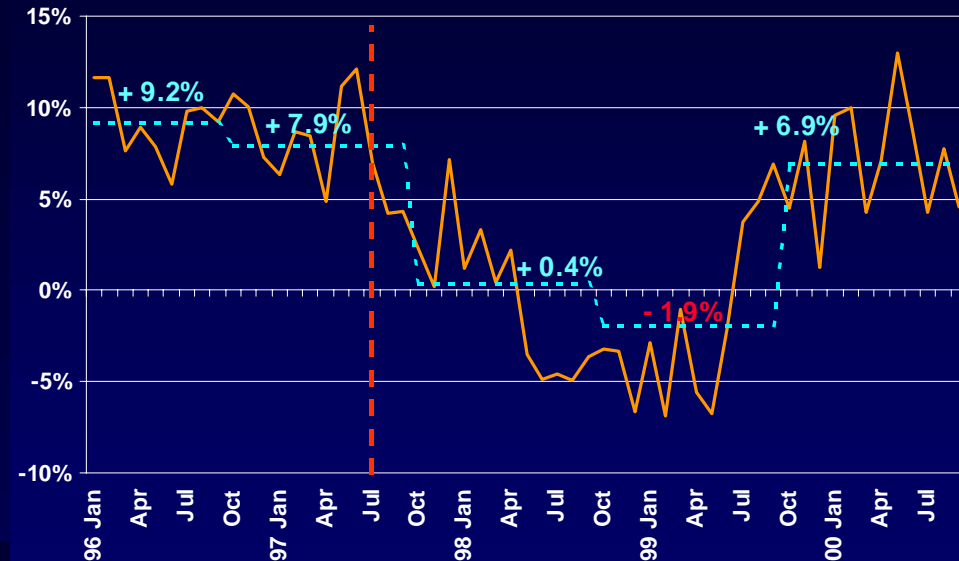


Data from EGAT Policy & Planning

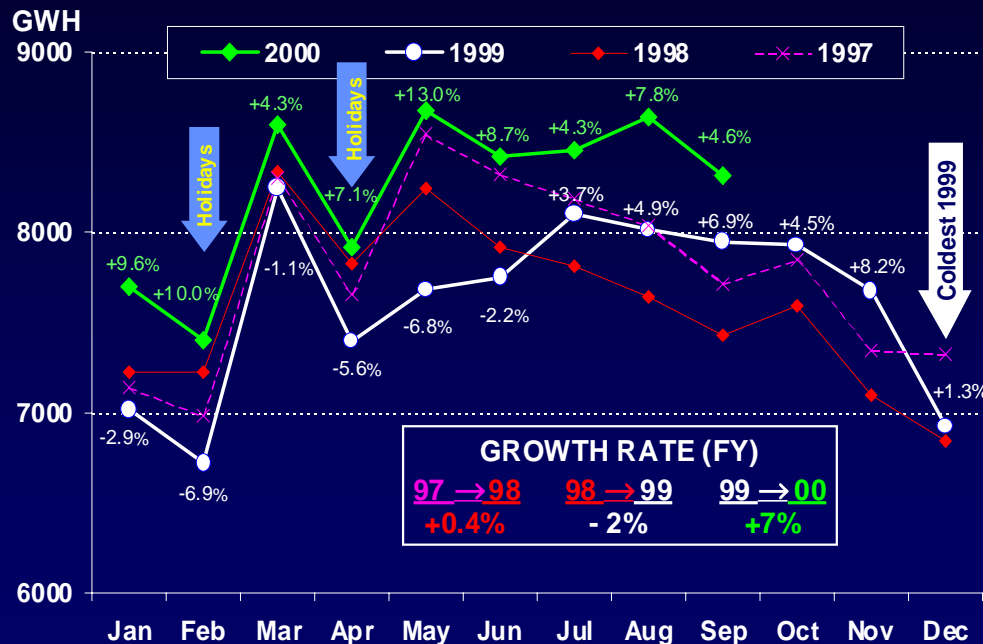
Has Recovered
and
Grows Again

Thailand's Electric Energy GWH Demand

Y-o-Y GWH Growth Rate



EGAT 1997-2000 Monthly GWH Generation

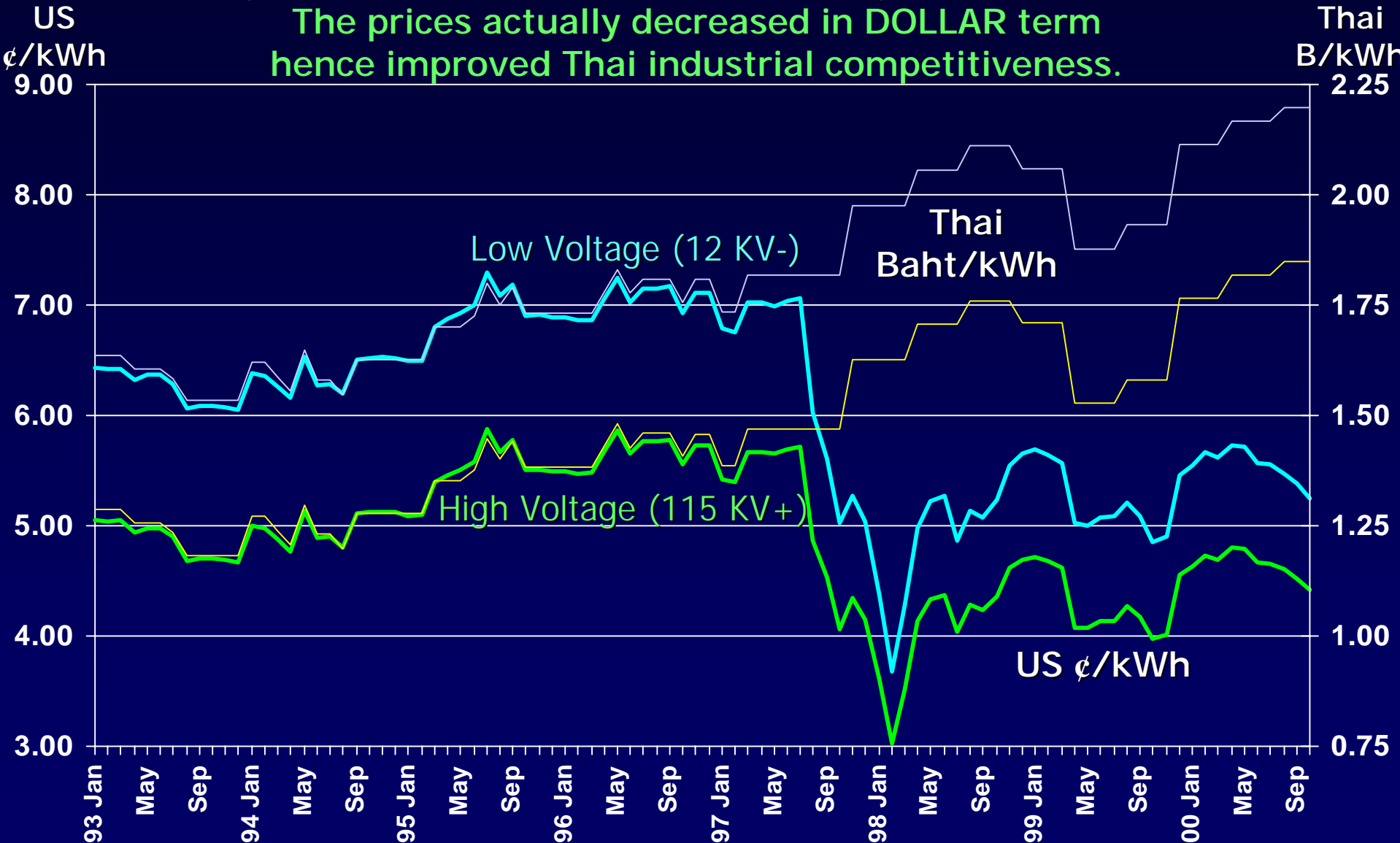


Has Recovered
and
Grows Again

Industrial Electricity Tariff with Ft

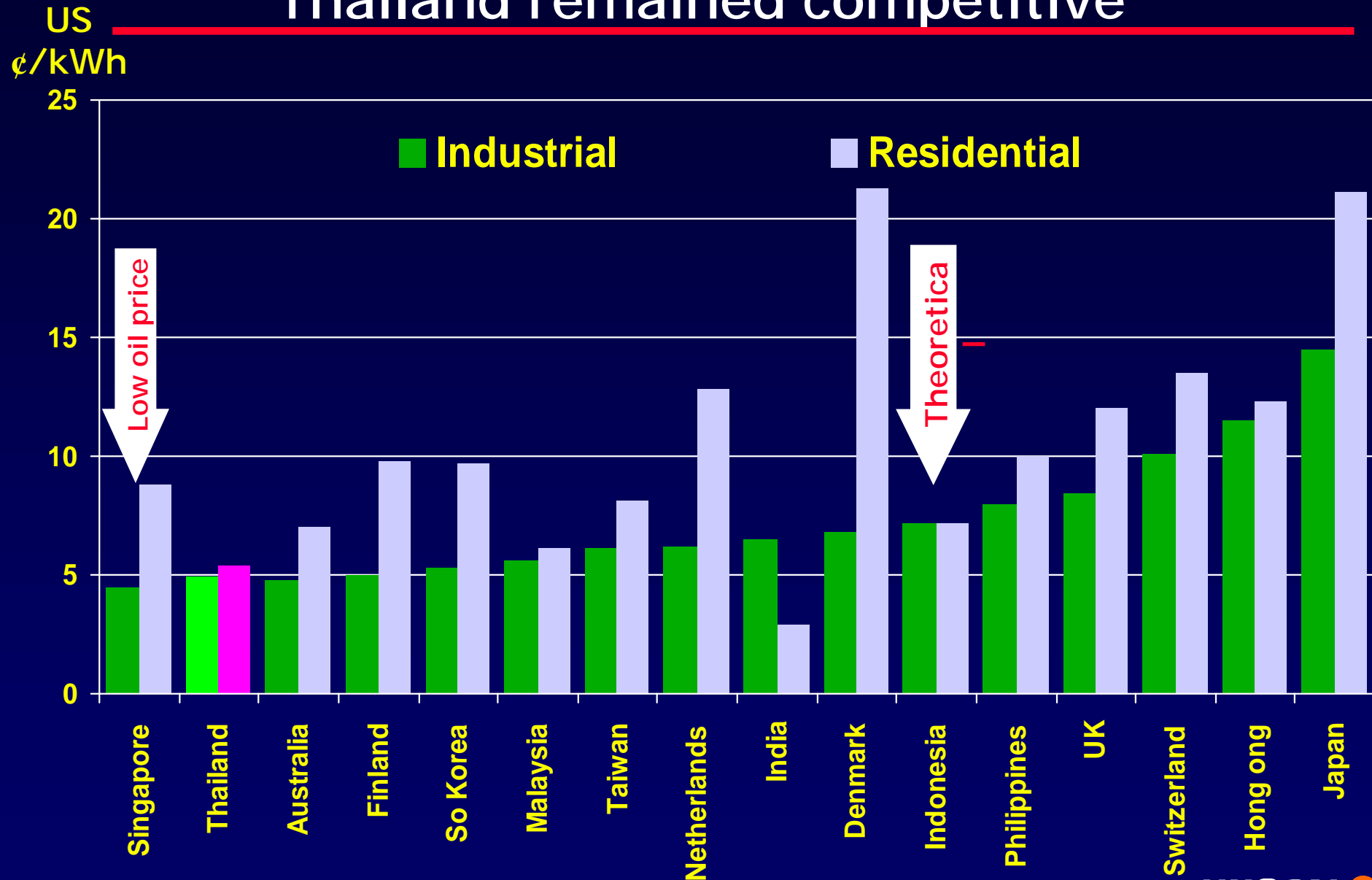
Electricity Prices increased in BAHT term after July 1997 BAHT devaluation.

The prices actually decreased in DOLLAR term
hence improved Thai industrial competitiveness.



1998 Electricity Prices of Selected Countries

Thailand remained competitive



National Development Priorities

- Peace

- ✍ an end to war, drugs, conflicts, prejudice and discrimination

- People

- ✍ education ✍ an end to illiteracy
 - ✍ moral triumph of human dignity

- Prosperity

- ✍ conquest of disease
 - ✍ an end to poverty
 - ✍ gainful employment

- Protection of Natural Environment